

Application of a new vanadium valence oxybarometer to basaltic glasses from the Earth, Moon, and Mars

**JIM M. KARNER,^{1,*} STEVEN R. SUTTON,^{2,3} JAMES J. PAPIKE,¹ CHARLES K. SHEARER,¹
JOHN H. JONES,⁴ AND MATT NEWVILLE³**

¹Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131, U.S.A.

²Department of Geophysical Sciences, University of Chicago, Chicago, Illinois 60637, U.S.A.

³Consortium for Advanced Radiation Sources, University of Chicago, Chicago, Illinois 60637, U.S.A.

⁴NASA Johnson Space Center, Houston, Texas 77058, U.S.A.

ABSTRACT

The redox states of volcanic and impact melts from the Earth, Moon, and Mars have been estimated from the valence state of V in basaltic glasses (Sutton et al. 2005). The V valence has been determined using synchrotron micro X-ray absorption near-edge structure spectroscopy (XANES) (Sutton et al. 2005), which allows for in situ measurements on samples with a micrometer spatial resolution and ~100 ppm elemental sensitivity. Here, we interpret those results for the natural samples and compare them to the literature. The results show that terrestrial melts are dominated by V⁴⁺, lunar samples by V³⁺, with Martian melts a mixture of both V³⁺ and V⁴⁺. The f_{O_2} estimates derived from the V valence are consistent with those determined by other proven methods, whereby terrestrial basalts experience f_{O_2} conditions within 1 or 2 log units of the QFM buffer, lunar basalts equilibrate at 1 to 2 log units below the IW buffer, and Martian basalts fall somewhere between the QFM and IW buffer. The results illustrate the usefulness of this technique; i.e., a robust oxybarometer covering over six orders of magnitude, applicable to samples that record f_{O_2} conditions from reduced extraterrestrial bodies to the oxidized Earth.

Keywords: Oxygen fugacity, planetary basalts, vanadium, oxidation state, Mars, XANES